Multiscale Information Science

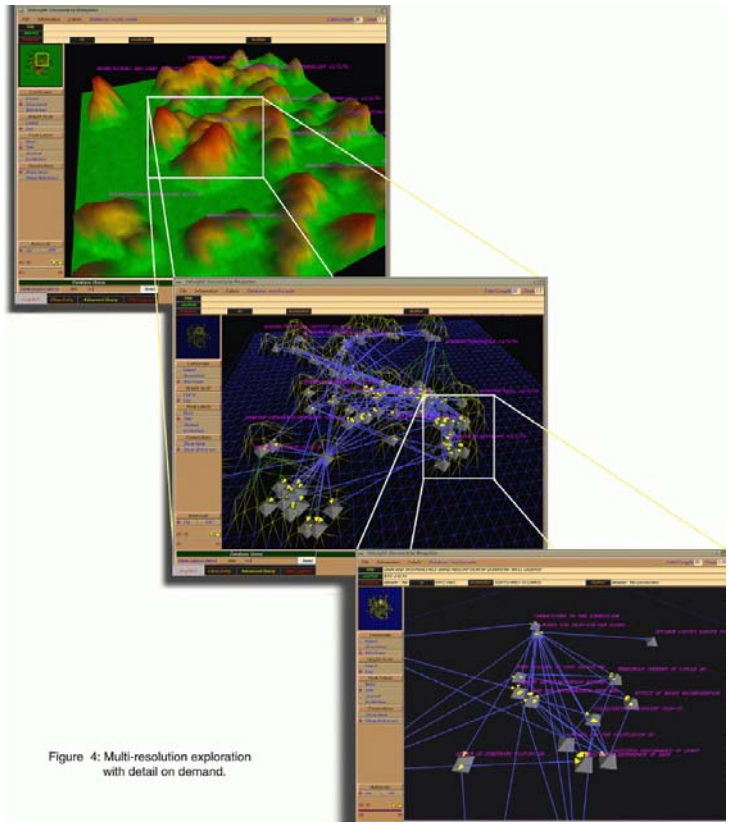

Figure 4: Multi-resolution exploration with detail on demand.

Information Science Group

- Mihai Anitescu
  - Stochastic optimization
  - Possible applications requiring “multiscale mathematics”
    - Seraching for detail in large data base of images
    - Geographical database search
    - Fast Queries for very large scale parametric partial differential equations.
    - Simulation of granular materials
    - General optimization-based simulation
- George Biros
  - Numerical methods for PDE’s and optimization
  - Applications
    - Geosciences….
    - Biomedical Flows
    - CFD
    - Fast Multipole methods
    - Molecular dynamics (femtoseconds to microseconds)
    - (lots of pictures)

Information Science Group (cont.)

- Bruce Hendrickson
  - Text and images represent huge repository of scientific information; information science is an essential scientific tool.
  - Visualization of abstract relationships
    - Multiscale
      - (clustering of scientific papers)
  - Dimensionality reduction in general
    - E.g. Google's page rank (link analysis via eigenvectors)
    - Latent Semantic analysis
  - Finding Multiscale Structure
    - Dewy Decimal System
    - Clustering scientific data
      - Vivismo search engine does clustering

Information Science Group (cont.)

- Terence Critchlow
  - Approximate queries using multi-resolution data
  - Data integration in bioinformatics
    - From DNA level to symptoms and treatments
  - What is multiscale information science?
    - Multiresolution data structures
    - Imposed hierarchies (clusters)
    - Visualization of high-dimensional data sets
- Pieter Swart
  - Experiments are critical!
  - Multiscale challenges in the discrete world
  - Finding the needle in the haystack
    - Hyperspectral imagery
    - Exploitation of nonlinearity and multiresolution
    - Face recognition test problem (has measure of success!)
  - Multiscale dynamics on complex networks (no current public tools!)
    - Biology: many applications
    - Social, sensor, extermal networks
  - Dynamics of the internet (worm dynamics, normal use dynamics)

Information Science Group (cont.)

- Lori Freitag
  - Unstructured adaptive mesh refinement
  - Data reduction for Interactive 3-d visualization
  - PDE's
  - Uncertainty quantification for data
- Tom Larson
  - "Selective physics"
  - Multiscale numerical methods integrated into decision support systems
- Pak Wong
  - Wavelet approximations, volume rendering
  - Dynamic visualization of transient data streams
  - Data mining, knowledge discovery
  - Network routing
- Rusty Lusk
  - Multiscale parallel program performance visualization

Information Science Group (cont.)

- Jim Thomas
  - Data intensive applications
  - Combine human and computer sides of analytics
  - Visual analytics (suite of tools from PNNL)
  - Mathematical data signatures
  - Predictive analytics
  - Dynamic structure for unanticipated data
- David Brown
  - Extraction of information from multimodal sources
    - Analogous to multiphysics simulations

Mathematics Themes for Multiscale Information Science

- Multiresolution analysis to find fast algorithms applicable to information beyond time series, images; example: dynamic networks
  - Wavelets, for example
  - Optimal clustering to preserve and discover information
  - Dimensionality reduction
  - Visualization in support of human understanding and communication
    - Not just classic simulation data
      - Full text landscape analysis for protein networks
- Data modeling
  - E.g. data representation of multi-modal form across scales
- Statistics
  - Identify sampling techniques that have higher-order convergence
    - E.g., randomized quasi Monte Carlo
  - Uncertainty quantification, example: non-PDE models
  - General issues in sampling: e.g., graph sampling
- General Needs
  - Support for large multidisciplinary scientific teams
  - Community Tools to encapsulate multiscale mathematics for applications
  - Data generation for algorithmic development and validation